DIRECTIONAL COUPLER

Models 138, 138A & 138A-1

OPERATING INSTRUCTIONS

Manufactured by

SIERRA ELECTRONIC CORPORATION
1050 Brittan Avenue
San Carlos, California

WARRANTY

SIERRA ELECTRONIC CORPORATION warrants instruments manufactured by it and bearing Sierra commercial model numbers, except Ion Gauge Tubes, to be free from defective material and factory workmanship and agrees to repair such instruments, which under normal use and service, disclose the defect to be the fault of our manufacturing. Our obligation under this warranty is limited to repairing any such instrument which in our sole opinion upon our examination proves to be so defective, when returned to our factory, transportation prepaid by the purchaser, within one year from the date of original purchase from us.

This warranty does not apply to any of our products which have been repaired, worked upon or altered by persons not authorized by us so as, in our sole judgement, to injure the stability or reliability of such instrument, or which have been subject to misuse, negligence or accident, or the serial number of which has been altered, effaced, or removed. Neither does this warranty apply to any of our products which have been connected, installed, used or adjusted otherwise than in accordance with the instructions furnished by us. Nor does SIERRA ELECTRONIC CORPORATION assume any liability for consequential damages, and in any event our liability shall in no case exceed the original purchase price of the instrument. Accessories, including but not limited to all vacuum tubes, fuses and batteries, not of our manufacture used with this product are not covered by this warranty.

SIERRA ELECTRONIC CORPORATION reserves the right to make changes in the design or construction of any of its instruments at any time without incurring any obligation to make any changes whatever on units previously purchased.

This warranty is in lieu of all other warranties expressed or implied and no representative or person is authorized to represent nor assume for us any liability in connection with the sale of our products other than that set forth herein.

SCI-195
July 18, 1956

OPERATING INSTRUCTIONS

DIRECTIONAL COUPLER

Models 138 & 138A-1

I. GENERAL

The Model 138 (or 138A) coupler is a "four terminal" network designed to be used with an external voltmeter and terminating resistance to measure either the incident or reflected waves existing in the primary coaxial transmission line. The coupler may be used to measure reflection coefficient, monitor power, mix signals, or isolate signal sources.

II. SPECIFICATIONS

1. Primary line impedance: Model 138 = 51.5 ± .5 ohms
   Model 138A = 50.0 ± .5 ohms

2. Secondary line impedance: 51.5 ohms ± 1 ohm

3. COUPLING FACTOR (defined as the ratio between power applied to primary line and power derived from secondary line):

   49.5 db ± 1 db at 100 mc (typical values). Decreases 6 db per octave with increasing frequency. See attached graph.

4. DIRECTIVITY (defined as the ratio between forward and reverse powers in the secondary line when unidirectional power exists in the primary line.

   61 db ±3 db at 100 mc (typical values). Decreases 6 db per octave with increasing frequency. See attached graph.

III CIRCUIT DESCRIPTION AND OPERATING THEORY

The straight primary line is coupled within the coupler body to the parallel section of the secondary line through a small hole in the wall between the two lines, thus providing both inductive and capacitive coupling between them. See Fig. 1 below. A small screw is provided in the secondary line center conductor to permit adjustment of the capacitive component of coupling. The value of the mutual inductance is controlled by the hole diameter and is not adjustable.

FIG I

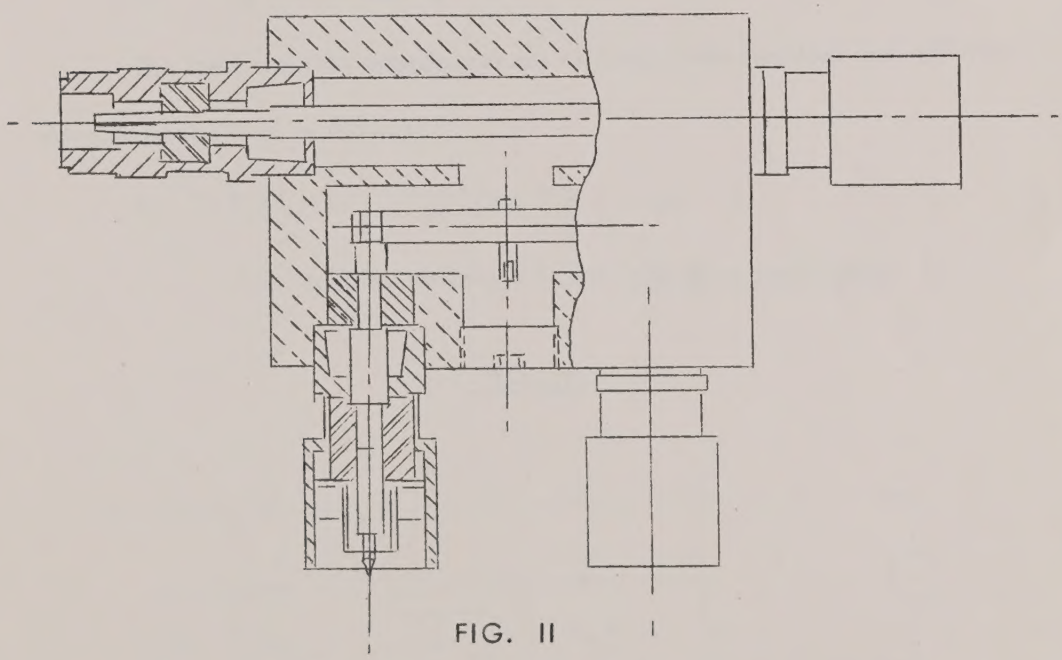
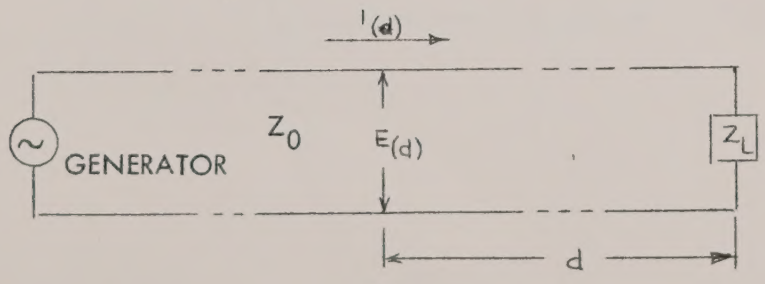
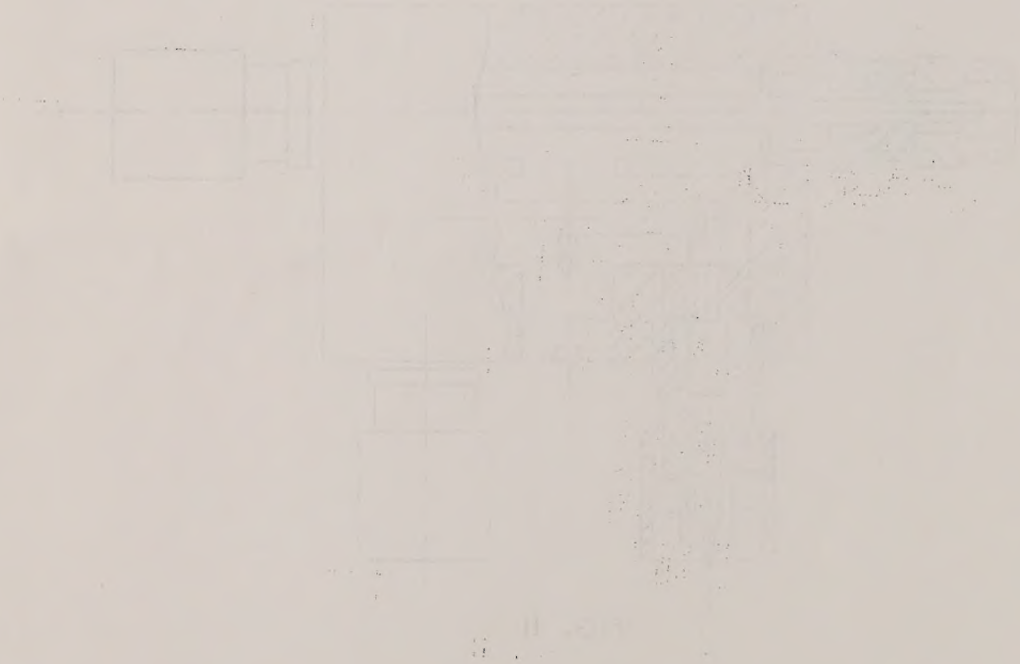


FIG. II





In Fig. II a generator is shown connected to a load impedance Z_1 through an arbitrary length of transmission line of characteristic impedance Z_o. At any point to the left of the load a distance d, a line-to-line voltage E_d and a line current I_d can be measured. It has been shown that both E_d and I_d are composed of the vector sums of incident and reflected components. The vector relations are:

1. $E_d = E_i + E_r$, and
2. $I_d = (E_i - E_r)/Z_o$

Where E_i is the incident wave voltage and E_r the reflected wave voltage.

The load and line impedances are related to the incident and reflected voltages at the load as follows:

3. $E_r/E_i = (Z_1 - Z_o)/(Z_1 + Z_o) = \rho \angle \phi$

This equation defines ρ as the <u>reflection coefficient.</u>

FIG. III

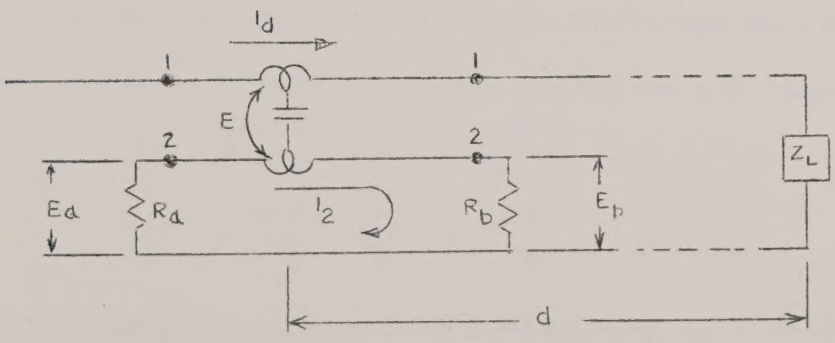


Fig. III shows the equivalent circuit of the coupler connected to a load through a transmission line. For convenience, no attempt is made to show the line as coaxial. The primary line 1-1 is coupled to the secondary line 2-2 by M and C as explained above. Terminating resistors R_a and R_b are connected to the secondary line. Following is a derivation of the voltages E_a and E_b developed across the terminating resistors R_a and R_b:

First, the voltage developed across $R_a = R_b = R$ due to the capacitive coupling alone is:

4. $$V_{rc} = \frac{R/2}{R/2 - j\frac{1}{\omega c}} E_d = \frac{\omega CR}{\omega CR - j\,2} E_d$$

5. Since $\omega CR << 1$, 5 becomes

6. $$V_{rc} \cong j \frac{\omega CR}{2} E_d$$

Next, the voltages developed across R_a and R_b due to the coupling through M alone are:

7. $$V_{rm} = - \frac{j\omega M}{2} I_d = i_2 R_b = i_2 R_a$$

Since the circuit elements are linear, the total voltage across each resistor is that due to the capacitive coupling plus that due to the magnetic, or:

8.
$$E_a = j\frac{\omega CR}{2} E_d - j\frac{\omega M}{2} I_d$$
$$E_b = j\frac{\omega CR}{2} E_d + j\frac{\omega M}{2} I_d$$

Substituting relations 1 and 2 into 8 and adjusting, (by means of the screw referred to above):

9. $C = \frac{M}{R Z_o}$ we have,

10. $E_a = j\omega CRE_r = j \frac{\omega M}{Z_o} E_r$ and,

$E_b = j\omega CRE_i = j \frac{\omega M}{Z_o} E_i$ which is the result desired.

Note that the reciprocal of either coefficient of E_i in 10 is the coupling factor.

The directivity of the coupler is determined by how scrupulously condition 5 is met. In this case, if the primary line is perfectly matched, i.e., $E_r = 0$, and if equation 4, rather than the approximation 6, is substituted into 8 we find:

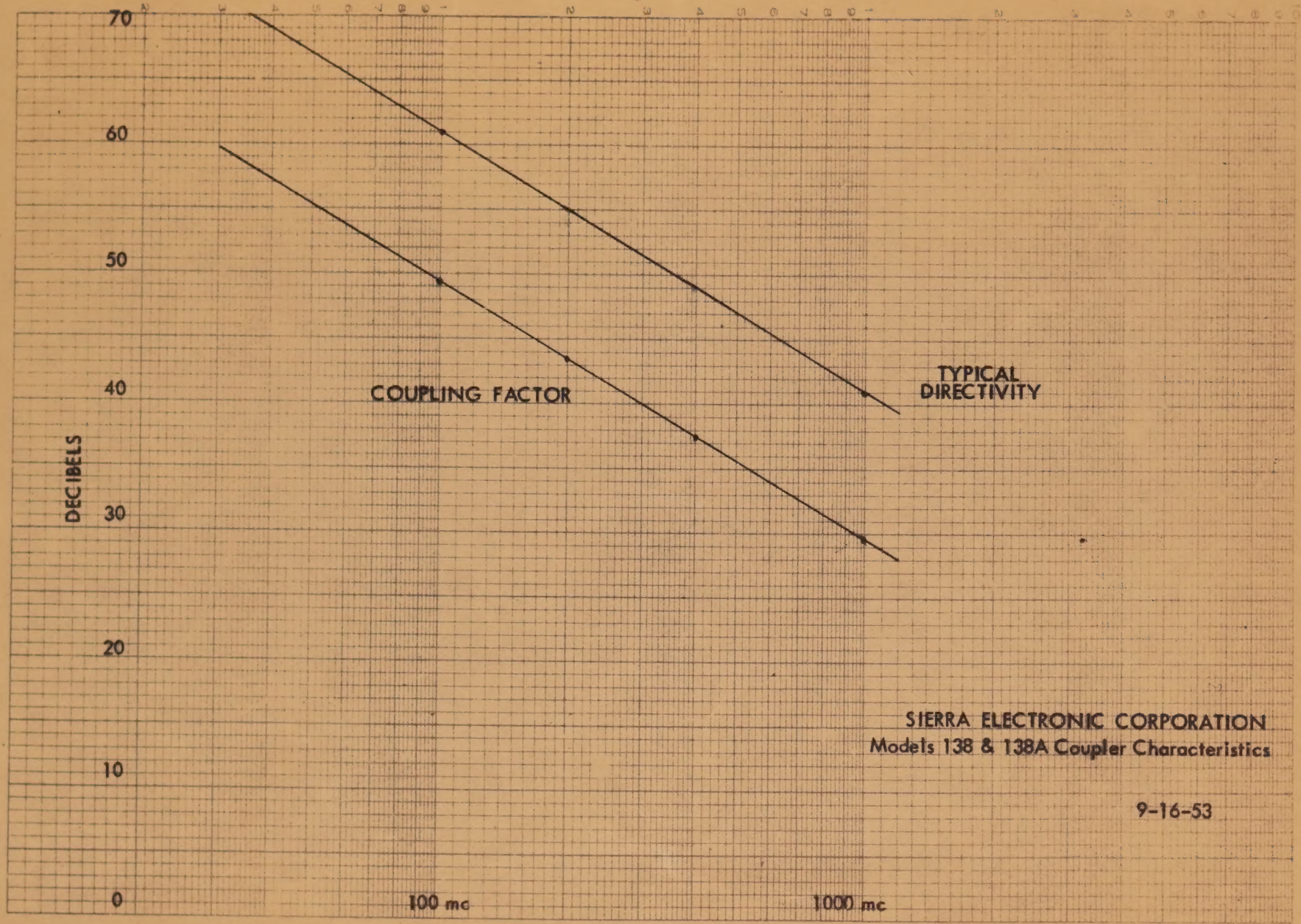
11. $\frac{E_B}{E_A} = \frac{4 + j\omega CR}{-j\omega CR} \cong \frac{4}{-j\omega CR}$

This is the ideal directivity for the Model 138 coupler. Note that it is four times the coupling factor at every frequency. Discontinuities in the coupler fittings and in the secondary line bends cause the directivity to vary around this figure by plus or minus 3 db over the frequency range from 30 to 1200 mc.

IV APPLICATION NOTES

Each coupler is tested for performance at the factory before shipment. The resistor used to terminate the secondary line during testing has a value of 51.50 ohms and no measurable reactance at 500.00 mc where adjustments are made. If the secondary line termination employed by the purchaser is not identical to that used in the factory tests the directivity and sensitivity will be affected. The user

may desire to adjust the coupler to optimize performance using his particular terminations. This is accomplished by removing the screw plug between the E_r and E_i terminals and by adjusting the capacitor screw thus exposed with an insulated screwdriver. CAUTION: Avoid bending the secondary line center conductor, and be sure that no foreign matter enters the coupler.



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Models 138 & 138A Coupler Characteristics

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